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Simplified Heat Engine

In a new Sterling-cycle heat engine, heat absorbed from an external source expands a gas that acts on a piston to perform work. The engine is shown in Figure 1; an interesting feature is the pneumatic system used to drive the displacer/regenerator, thus eliminating mechanical linkages and valves. The essential features are a "constant-pressure" chamber (P_0) the displacer/regenerator, and a drive piston.

The operation and features of the engine can be best understood by following through a single cycle. In Figure 1(a), the piston and the displacer are both at their lowest points, and most of the working gas is in the area referred to as the cold chamber. The working-gas pressure, P_1, is less than P_0. These conditions correspond to point (a) on the indicator diagram of Figure 2.

A flywheel causes the crankshaft to continue to rotate, move the piston upward, and begin compressing the working fluid. At some point, pressure P_1 exceeds P_0 [(b) in Figure 2], and the displacer is forced upward into chamber P_0 as shown in Figure 1(b). (In practice, the volume of chamber P_0 is much larger than the volume of the working-gas chamber so that P_0 remains relatively constant despite the piston motion.)

As the porous displacer moves upward, gas is displaced from the cold chamber to the hot chamber, absorbing some previously deposited heat as it passes through the displacer/regenerator. The working fluid absorbs further heat from the heat-transfer manifold. This continues until the piston and the displacer are at their uppermost positions[Figure 1(c) and point (c) in Figure 2].

At this point, temperature and pressure are at a maximum, and the working gas will expand and push the drive piston downward, which applies a rotational force to the crankshaft and flywheel. The flywheel inertia causes the piston to continue past the point

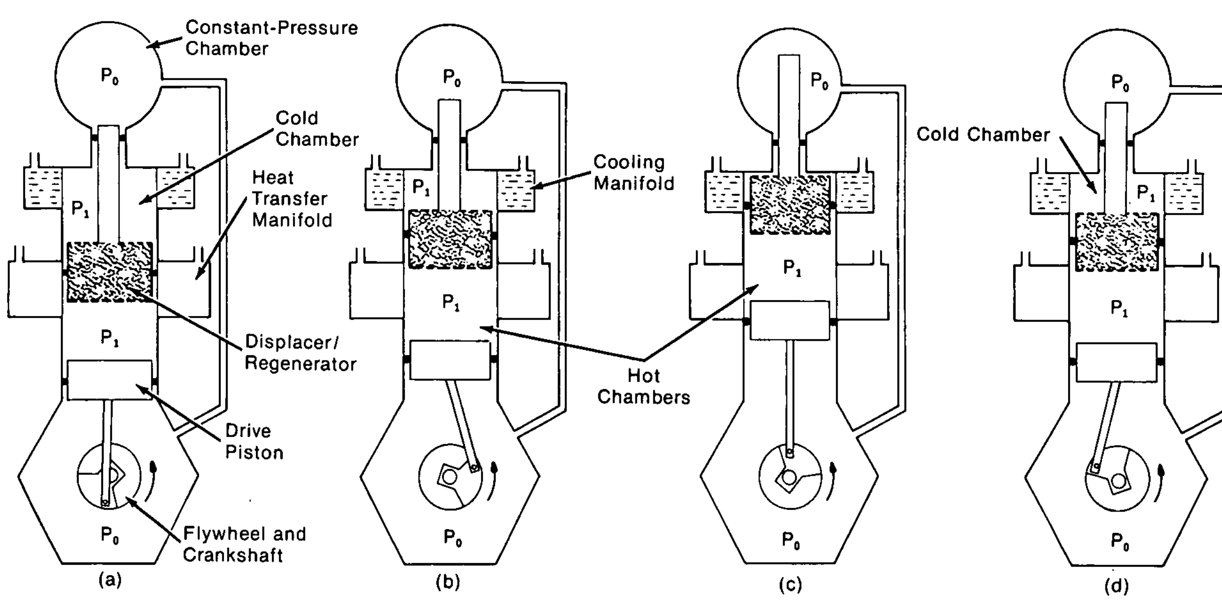

Figure 1. Simplified-Heat-Engine Cycle

(continued overleaf)

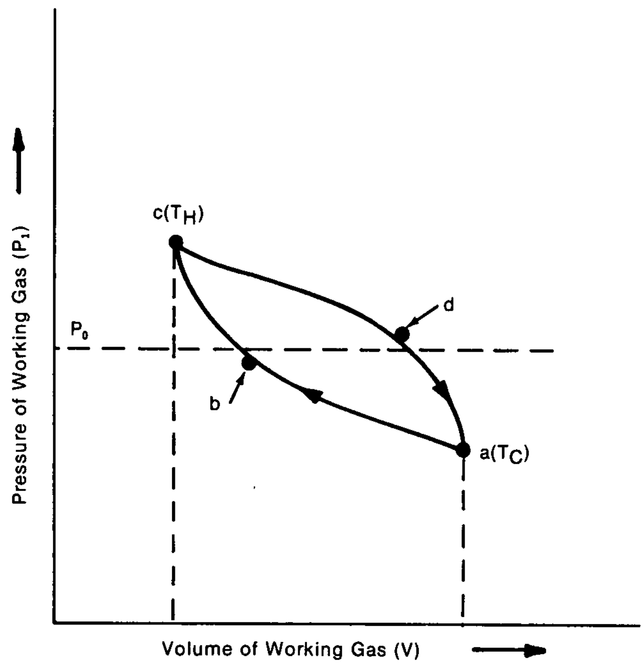

Figure 2. Pressure/Volume Indicator Diagram for Heat Engine

where $P_1 = P_0$. The continued expansion and the resulting cooling make P_1 less than P_0 [Figure 1(d) and point (d) on Figure 2], and the displacer/regenerator is forced downward.

While the displacer was in the cold chamber, its temperature was lowered somewhat by the cooling manifold; at the same time, the working gas was heated. Thus, as the gas passes back through the regenerator and into the cold chamber, some of its heat is absorbed by the regenerator. The gas is further cooled in the cold chamber. When the piston reaches its lowest point, the cycle is back at the state indicated in Figure 1(a) and point (a) of Figure 2.

The timing of the pressure variations and of the piston and displacer motions is obtained by selecting the appropriate flywheel moment of inertia, the amount of working gas, pressure P_0, and the difference between chamber temperatures. As can be seen from Figure 2, heat absorbed by the gas at a high temperature results in expansion and yields work equal to the area of path abcda. Typical conditions are $T_H = 800$ K (980° F), $T_C = 370$ K (210° F), and $P_0 = 1.38 \times 10^6$ N/m^2 (200 psi). The displacer/regenerator can be packed with steel wool or can be a solid-cylinder displacer with the regenerator outside the engine housing.

The engine is only moderately efficient, but it could be particularly useful with nuclear reactors where there might be large quantities of otherwise-wasted heat and where the reduced maintenance is important. With only a few modifications, the engine could also be used as a refrigerator.

Note:

Requests for further information may be directed to:

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Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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